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Comparative study of suitable power semiconductor devices for induction heating applications

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ABSTRACT

The modern technology advancement follows the evolution of power semiconductor devices. This power semiconductor device represents the heart of modern power electronics and it has the main task of modulating the energy flow to suit the demands of the application with the proliferation of choices between MOSFETS and IGBTS, it is becoming increasingly difficult for today's designer to select the best device for the suited application. In this paper the comparative simulation analysis of MOSFETS and IGBTS was done by analyzing various parameters, it offers significant performance improvements in induction heating applications by adopting

best power semiconductor devices. The analysis was done using the design software and the multi sim where in which, the prominent differences that make these switching devices suitable for appropriate application were identified.

Keywords:
IGBT; Induction heating; MOSFET; Switching frequency; TINA.

Abbreviations:
Metal-Oxide Semiconductor Field-Effect Transistor(MOSFET);Insulated-GateBipolar Transistor(IGBT); Phased Locked Loop(PLL);Pulse Width Modulation(PWM); Zero Current Switching(ZCS); Zero Voltage Switching(ZVS); Permanent Magnet DC(PMDC); Pulse delta Modulation(PDM).

1. INTRODUCTION

A power semiconductor is a semiconductor device used as a switch or rectifier. Due to improvements in the MOSFET technology (Metal Oxide Semiconductor Technology, initially developed to produce integrated circuits), the power MOSFET became available in late 1970. This module has the power control ability of the bipolar transistor and the benefits of the isolated gate drive of the power MOSFET.

Power semiconductor devices analyzed using the induction heating application. Induction heating is the method of heating an electrically conducting required object usually the eddy currents create their own magnetic field that opposes the original field produced by the coil& a metal. There are many types of induction heating applications MOSFET are used the high temperature, high efficiency, and better performance.

KevadiyaKetan et al. [1] described induction melting furnace model is designed for an induction model with IGBT based parallel inverter. Then voltage, current and power factor is measured. This value was compared with actual data of induction melting furnace. In this, the conventional method has SCR based inverter, and this SCR was replaced by IGBT.

Ramya L.R et al. [2] described Induction heating is an efficient non-contact technique for heating metals. Series and parallel resonant inverters were widely used in switching schemes. A modified three phase inverter with full bridge topology by using changing the modulation asymmetrical voltage cancellation control is implemented for induction heating applications and also protect the reduces the power losses and increased current with high frequency.

RonalS.et al. [3] described Comparison the thyristor- based inverter and IGBT based inverter.Inverter using IGBT with SPWM technique, control of output voltage of induction furnace is possible by changing modulation.Rectifier section is diode based for the simplicity makes to compare the resonance circuit.

Kulkarni.V.Vet al. [4] described high-frequency resonant converters are used widely for induction heating. Resonant inverter to achieve the desired high frequency with reduced switching losses and simulating the power electronic converter circuit using Simulink for induction heating equipment. The output power of the load coil varied by changing the frequency of the inverter. The MOSFET instead of the IGBT and main features of the proposed inverter are simple PWM control strategy and high performance.

VasudhaGujar et al. [5] described inverter topology method was developed for induction heating application. The inverter to achieve the desired high- frequency with reducing switching losses.The Voltage source and current source inverters both using ZCS and ZVS are analyzed. The output power due to minimized switching losses.

Mehar Ali Md et al. [6] described a half-bridge resonant-type inverter method suitable for modulating heating magnetic and nonmagnetic materials at the high frequency.The series-parallel methods have proposed an arrangement of capacitors is adopted, and an optimum mode of operation. The provided reasonably accurate information with respect to the inverter output currents, current gain, and system efficiency.

Nithya.R et al. [7] described industrial induction heating application. It is a process used for heat conductive materials, like the bond, harden, and soften metals. Series resonant inverters which are made up of IGBT. Power control has been acquired by Hysteresis Current Control (HCC). This method switching losses were not minimized since it is impossible to turn on and turn off the switches at zero voltage and zero current at all times. Power control is done by hysteresis current method and provides the good response a varied range.Soft switching techniques were performed which minimized switching losses.

Govindaraj.T et al. [8] described a combination of MOSFET inverter and IGBT converter voltage switching technique based converter fed PMDC(Permanent Magnet DC).The proposed converter topology reduces voltage stress and conduction losses using zero voltage switching technique.The output due to less switching losses and requirements of power devices less.

Hakim. An et al. [9] described Induction Heating high- frequency inverter circuit is used, which can deliver output at different frequencies by Metal Oxide Semi-Conductor Field Effect Transistor (MOSFET).The series resonant inverter method is applied to provide Current Swapping (ZCS) for all changes the turn off condition, and Zero Voltage Switching at diode turn on. The output power of the load coil varied by changing the frequency of the inverter. The MOSFET instead of the IGBTand main features of the proposed inverter are simple voltage control strategy and high performance.The desired high frequency reduced by switching losses where resonant inverter being placed.

Gayathri.K et al. [10] described the series resonant inverter with PWM and PDM techniques for industrial heating applications. The series resonant inverter method had been proposed by comparative analysis was completed for PWM and PDM technique. The simulation allows to concluding that this PDM inverter is capable of improved efficiency an inverter and thus the output power increases by more than twice that of the inverter applying power control by classical frequency variation PDM inverter is more suitable for induction heating application at a high switching frequency.

PradipKumar Sadhu et al. [11] described an exhaustive method for the selection of different power semiconductor switches for high- frequency mirror inverter fed induction heater was presented. The power devices three terminal switches are engaged. This analysis selection of suitable power semiconductor switches like IGBT, GTO, and MOSFET are made the selection of IGBT as a power semiconductor switch in high-frequency mirror inverter.

Yongxing Wang et al. [12] described on IGBT Induction Heating Power Supply new method, using PLL and parallel inverter, a new control method using closed-loop rectifier control of voltage and current. Power control is done by closed loop methods are provide the good response a varied range.Soft switching techniques were performed which minimized switching losses.

Turki K. et al. [13] A half-bridge series parallel resonant inverter for induction heating applications. Pulse width modulation (PWM)-based dual integral sliding mode voltage controlled buck converter was proposed for method the induction heating power. A power MOSFET transistor was used as a switching device the buck converter and the IGBT transistor which is used as a switching device for the inverter.This simulation analysis controls the switching devices like voltage and control using induction heating application methods are proposed output power and speed, which minimized switching losses.

Javadi.H et al. [14] described a current source parallel-resonant inverter working for induction heating. The analysis is done in the frequency domain using Fourier series techniques to predict output power, efficiency, Dc-to-Ac voltage transmission function, and part voltage and current stresses.

Soni.R et al. [15] described high frequency three phase inverter circuit that can output the different frequency by Control Metal Oxide Semiconductor Field Effect Transistor (MOSFET) for induction heating. The simulation heating had often used for the heat-treatment of a metal piece. The proposed circuit cannot realize with the IGBT to output the high frequency. The component uses the Power MOSFET instead of the IGBT. To reducd switching losses and output stability.

In this paper to choose the pertinent devices for induction heating applications, the comparative simulation analysis of various parameters were analyzed.The characteristics of various power semiconductor devices were analyzed which could offer significant performance improvements in induction heating applications by adopting best power semiconductor devices.

2. PROPOSED METHOD

Induction Heating Application

MOSFET based Series Resonant inverter topology circuit is used. This works under two modes of operation. Fig.1. shows switching modes the series inverter. During mode switches, Q1 are turned on positive voltage and Q2 are turned of negative voltage.Both Q1and Q2 voltage and current across the load a series inverter.

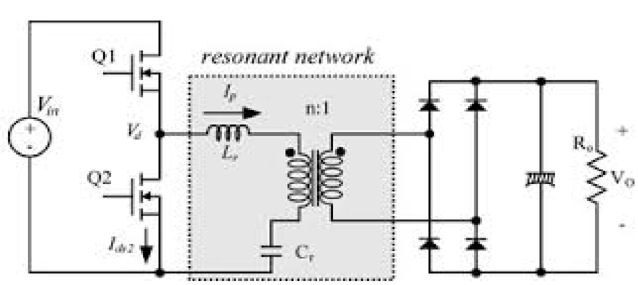

Figure 1

General circuit diagram of series inverter

3. METHODOLOGY

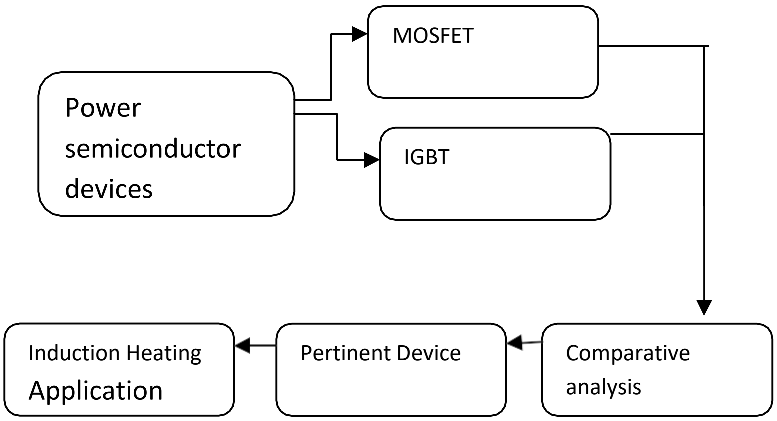

Figure 2

General block diagram

Block Diagram Description

Power semiconductor devices

The three terminal devices using analysis selection of suitable semiconductor switches like MOSFET, IGBT, and JFET.

MOSFET

This semiconductor device is output characteristics of gate transistor. The MOSFET majority carriers with high voltage and high efficiency.

IGBT

The IGBT combine with output characteristics of the bipolar transistor. The IGBT minority carriers with high impedance and high current.

Relative Analysis

The Power Semiconductor devices were compared and analyzed using the TINA software to improve the performance and efficiency and to choose the best devices for induction heating application.

4. RESULTS AND DISCUSSION

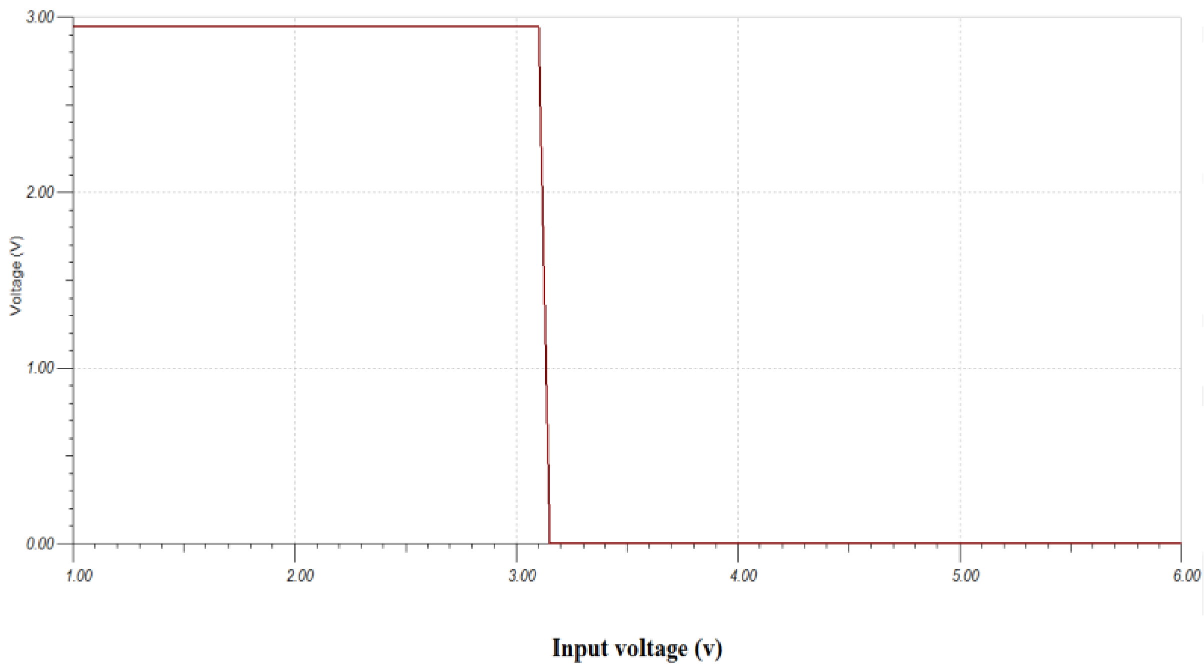

Figure 3
Depicts the DC analysis of MOSFET Power semiconductor device

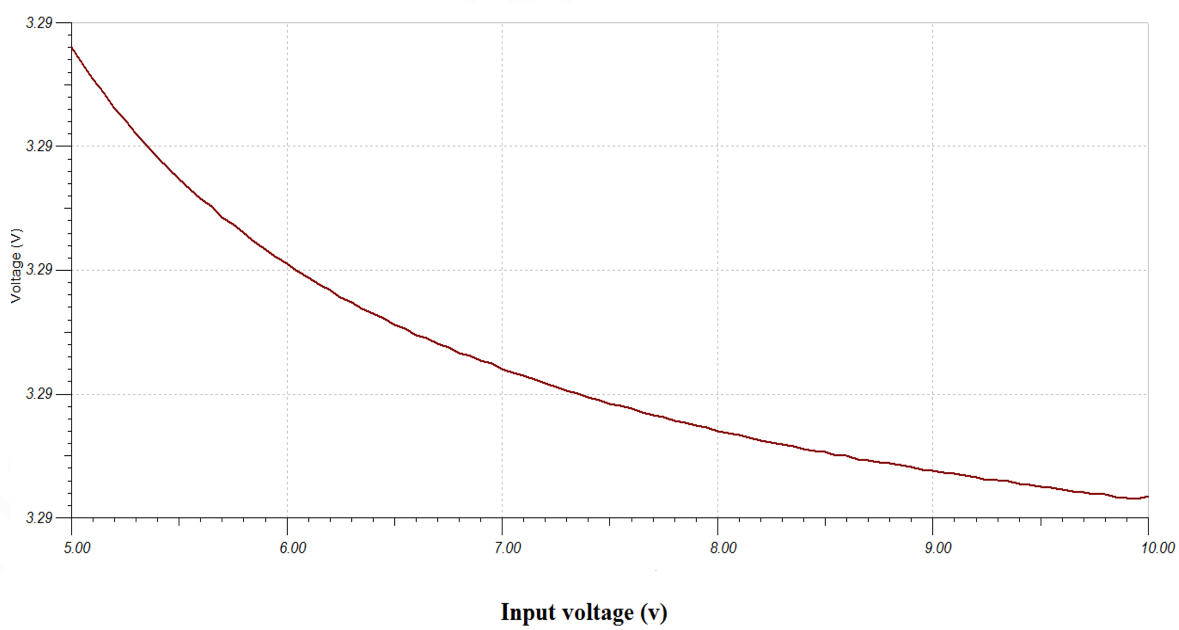

Figure 4
Depicts the DC analysis of IGBT Power Semiconductor device

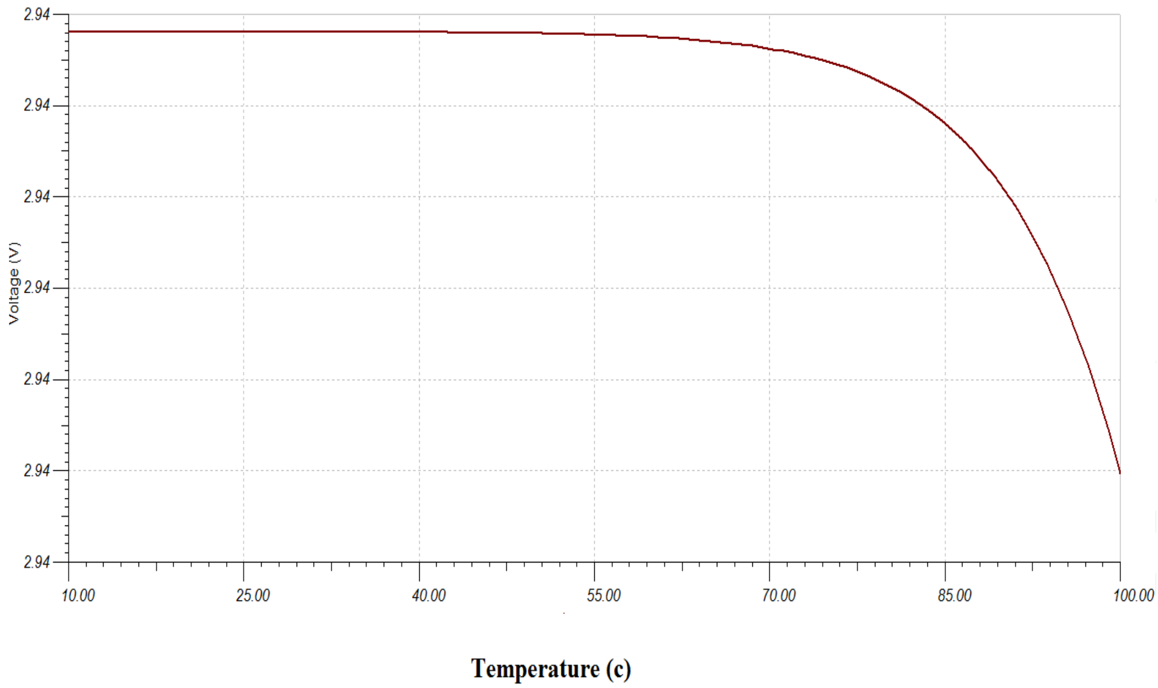

Figure 5
Depicts the temperature analysis of MOSFET Power Semiconductor device

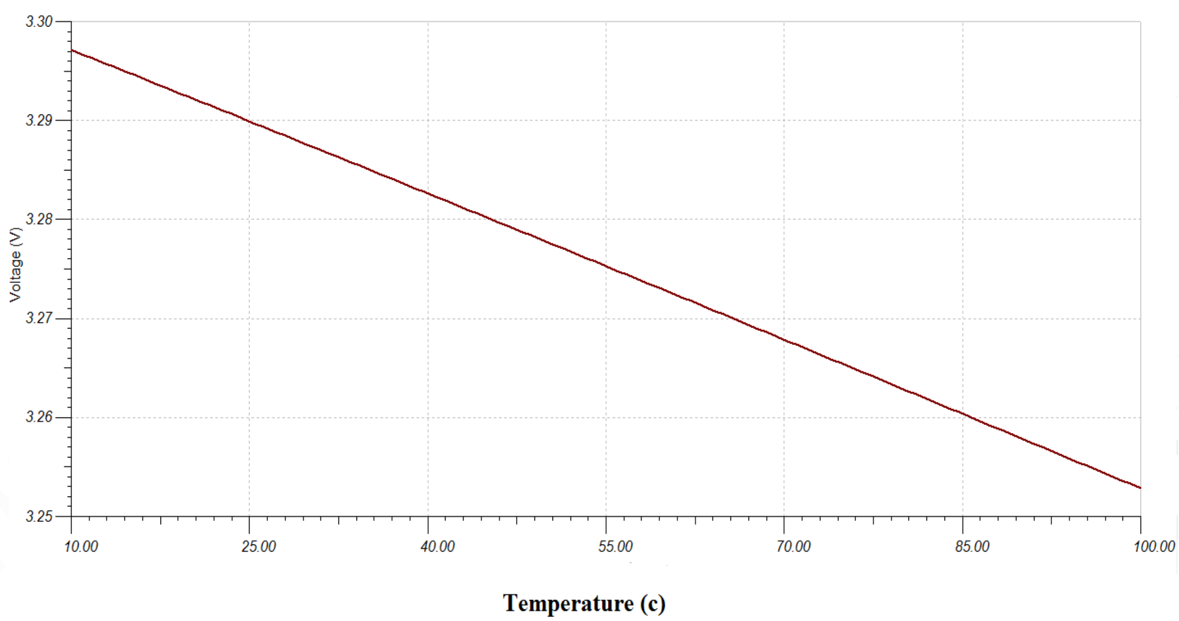

Figure 6
Depicts the temperature analysis of IGBT Power Semiconductor device

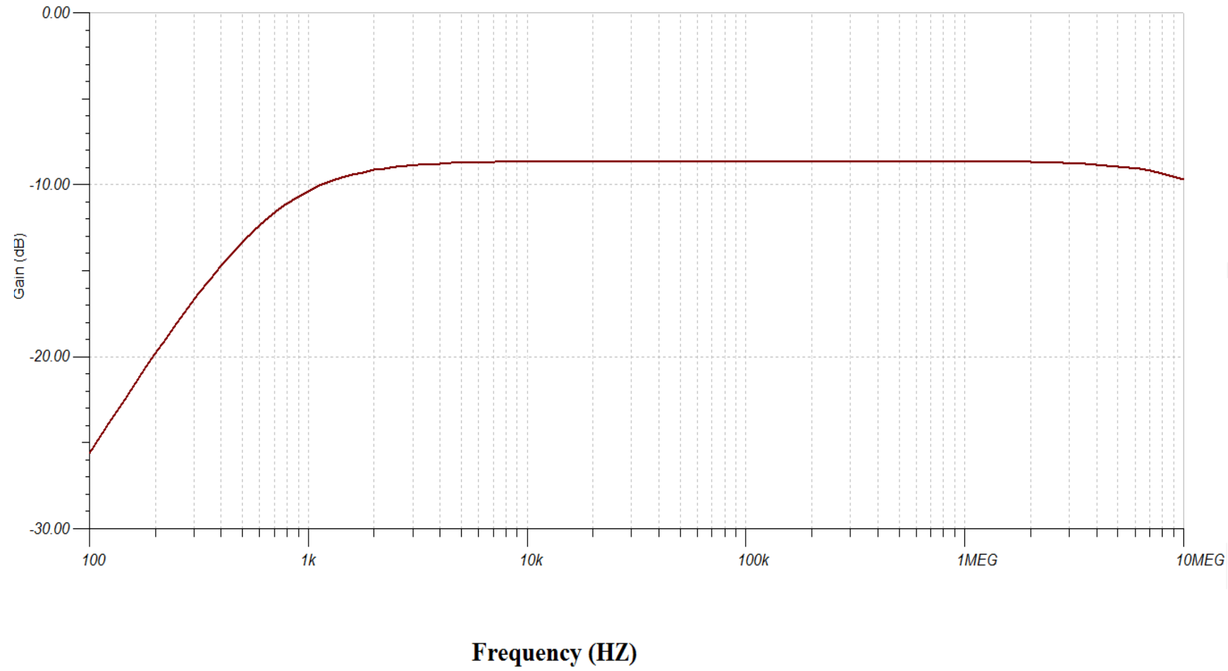

Figure 7
Depicts the AC analysis of MOSFET Power Semiconductor device

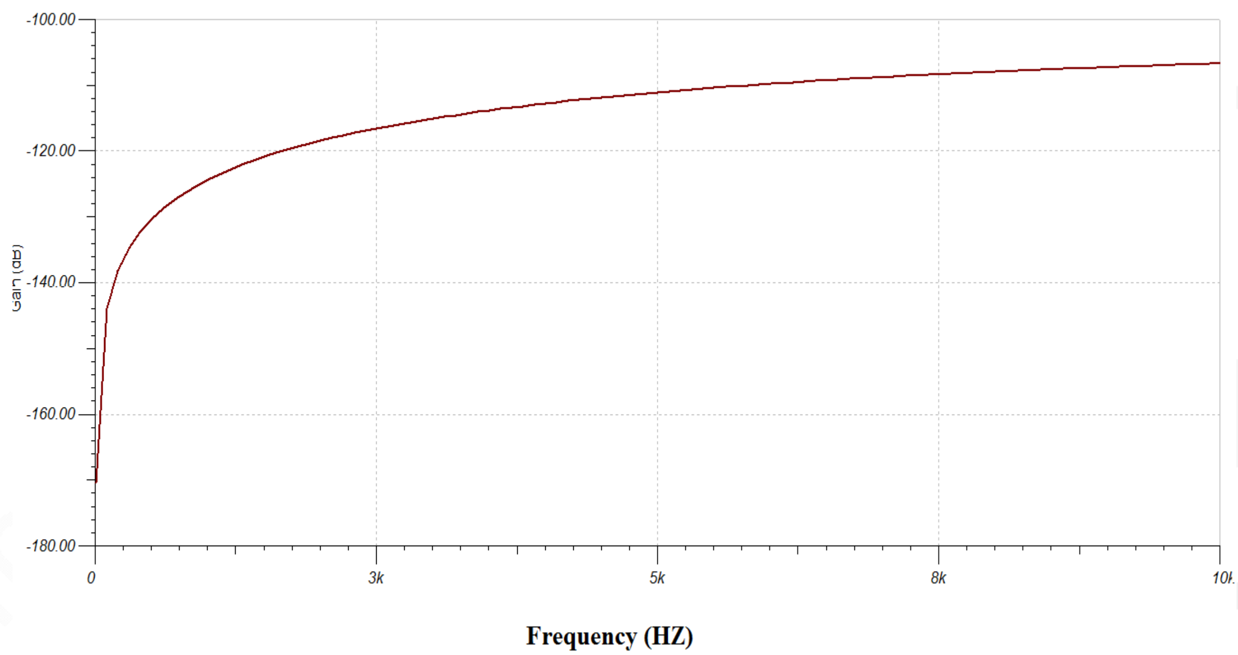

Figure 8
Depicts the AC analysis of IGBT Power Semiconductor device

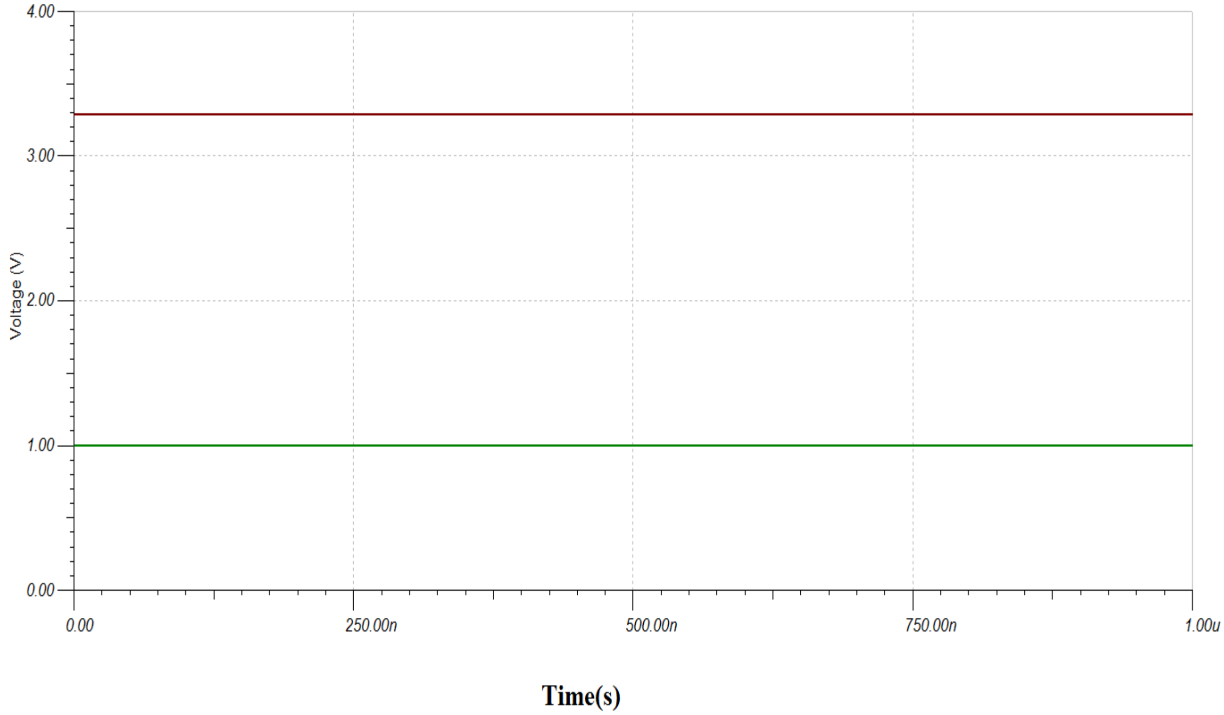

Figure 9
Depicts the Transient analysis of MOSFET Power semiconductor device

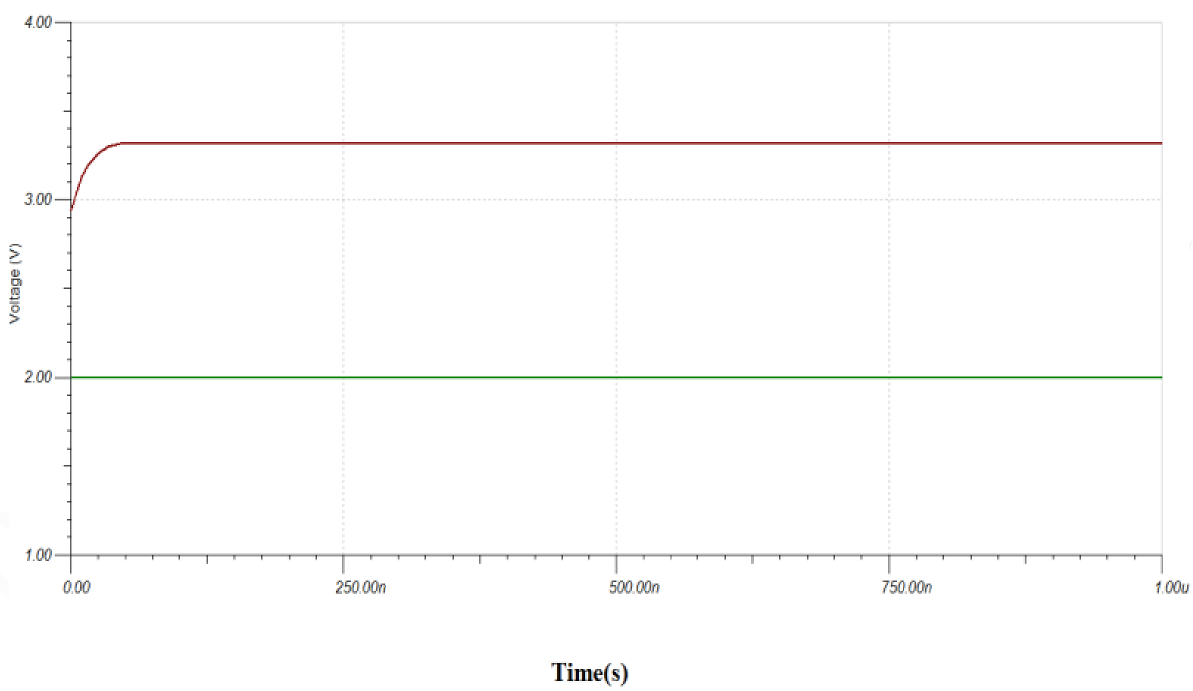

Figure 10
Depicts the Transient analysis of IGBT Power Semiconductor device

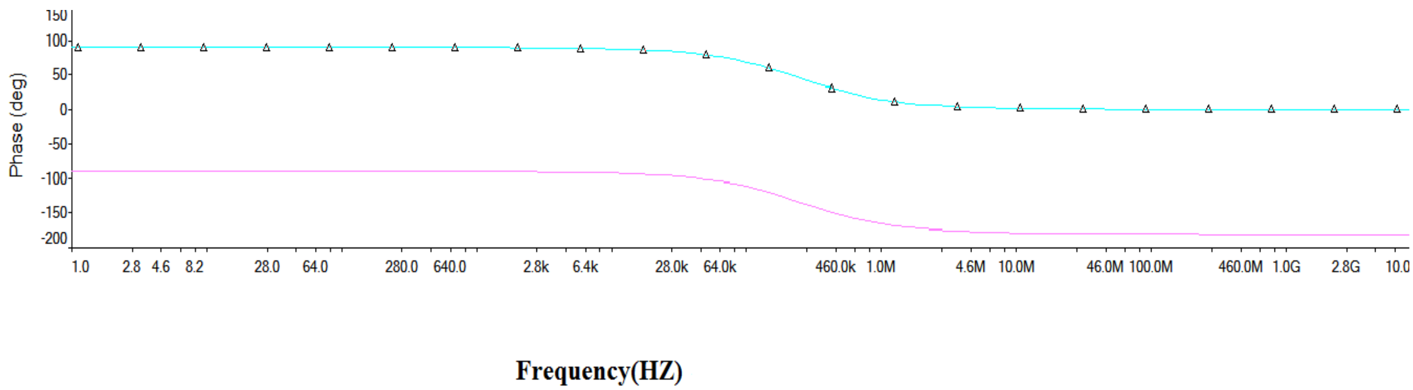

Figure 11
Depicts the AC analysis of JFET Power Semiconductor device

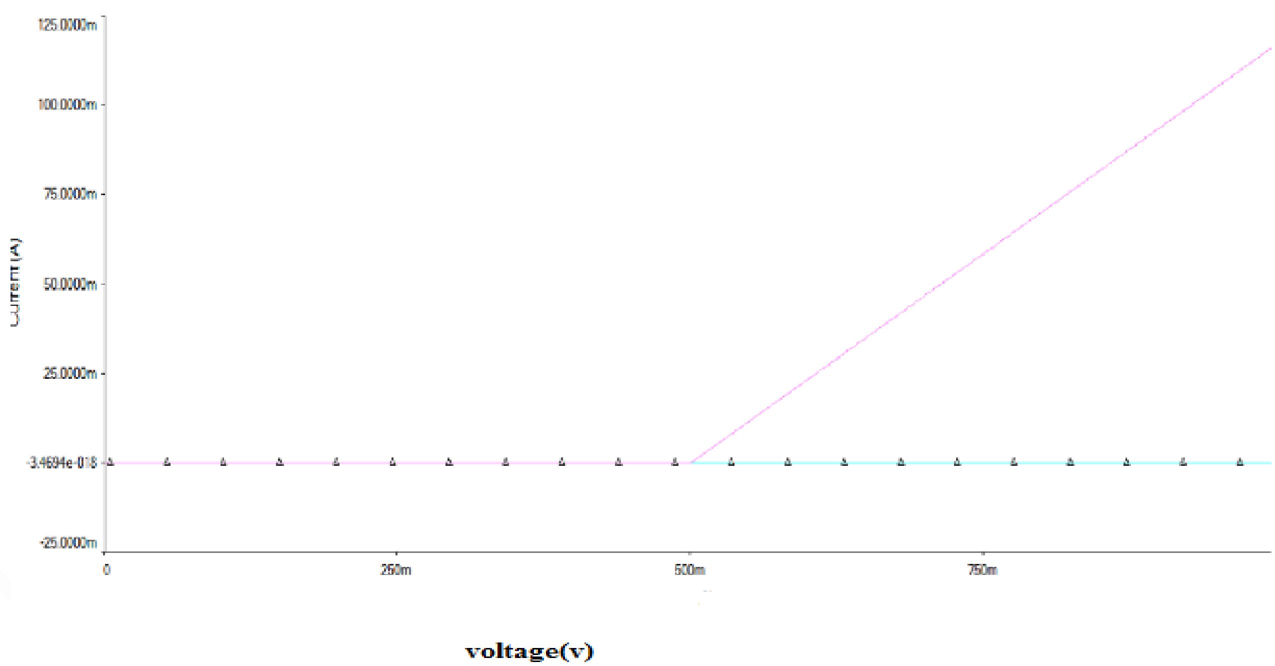

Figure 12
Depicts the Dc analysis of JFET Power Semiconductor device

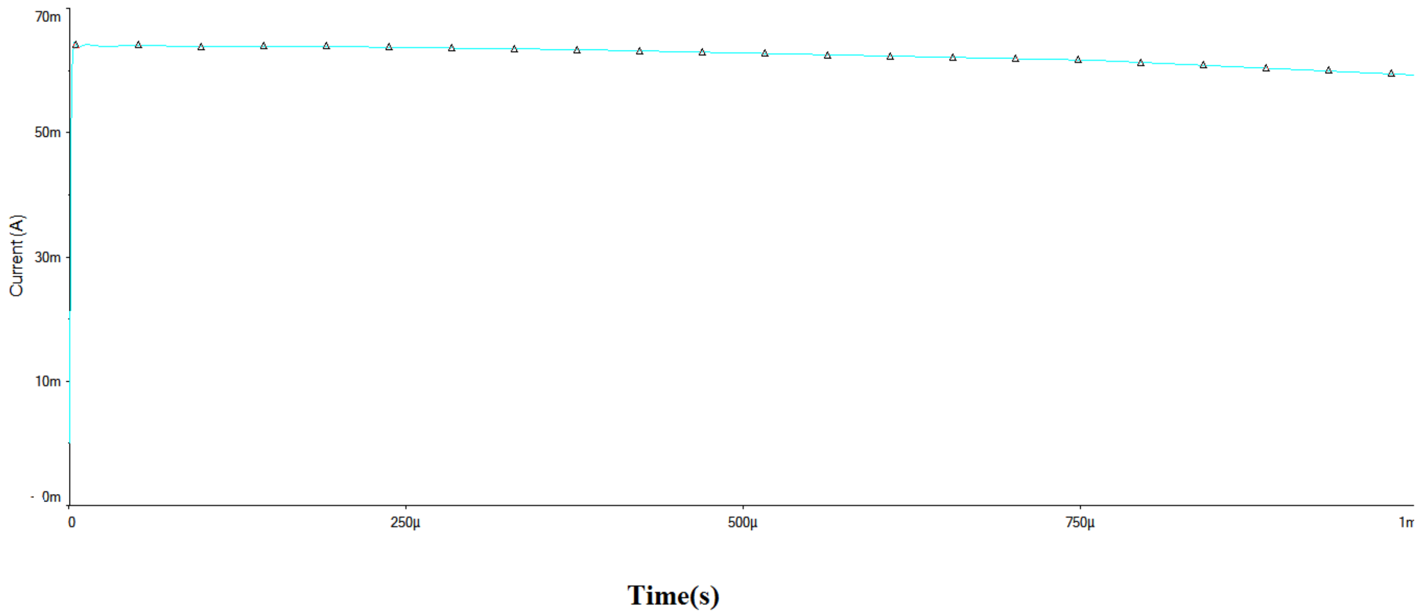

Figure 13
Depicts the transient analysis of JFET Power Semiconductor device

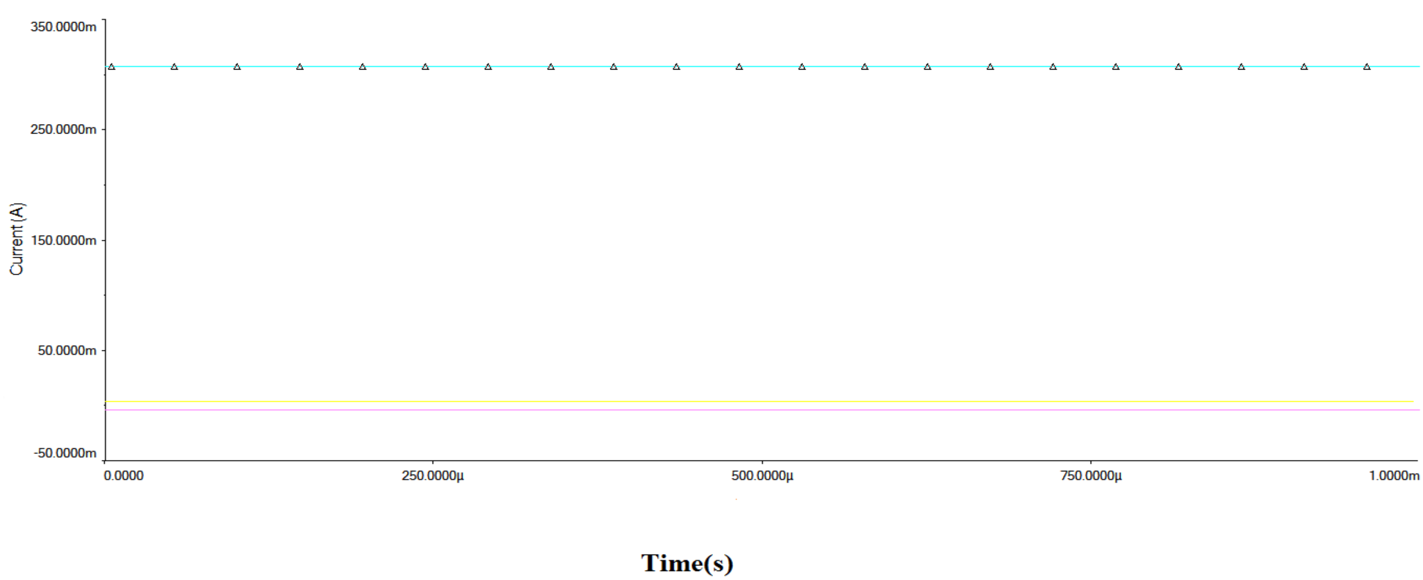

Figure 14
Depicts the Parameter sweep of JFET Power Semiconductor device

There is four type of analysis TINA software using the MOSFET, IGBT, and JFET. The analysis is discussed table given as below:

Table 1

Comparison of the MOSFET, IGBT, and JFET

Parameter/ characteristics	MOSFET	IGBT	JFET
DC analysis	Low Frequency	High Frequency	Medium Frequency
AC analysis	Low Current	High Current	Low Current
Transient analysis	Low	High	Low
Temperature analysis	Very High	Low	Low

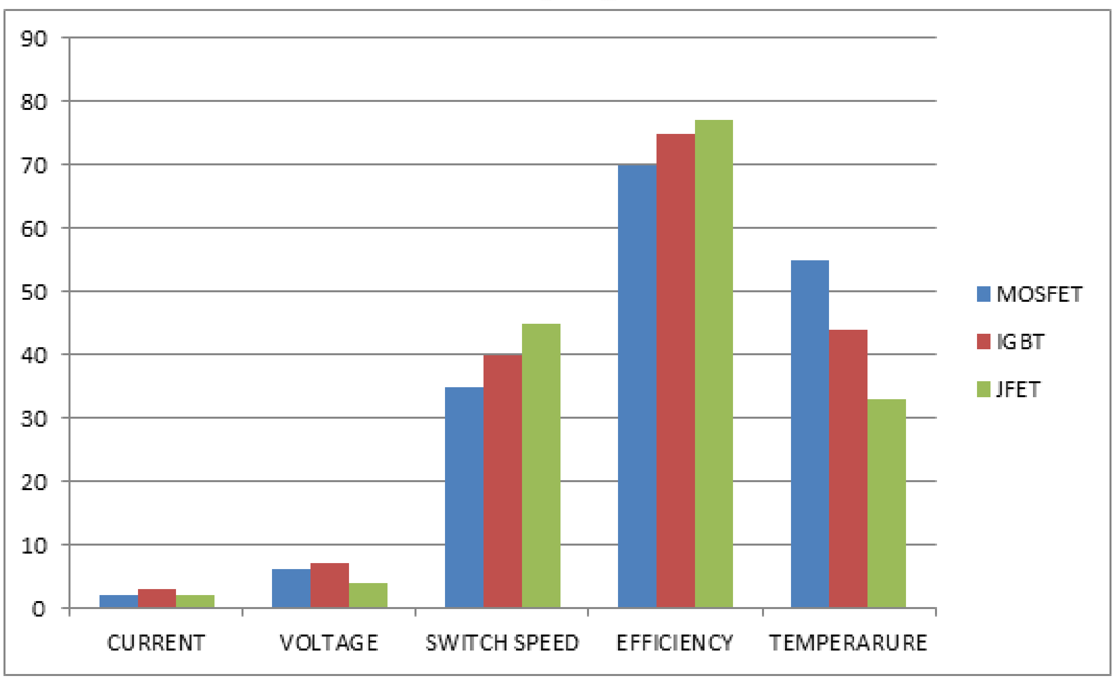

Figure 15

Comparison Graph of MOSFET, IGBT, and JFET

Series Inverter Results

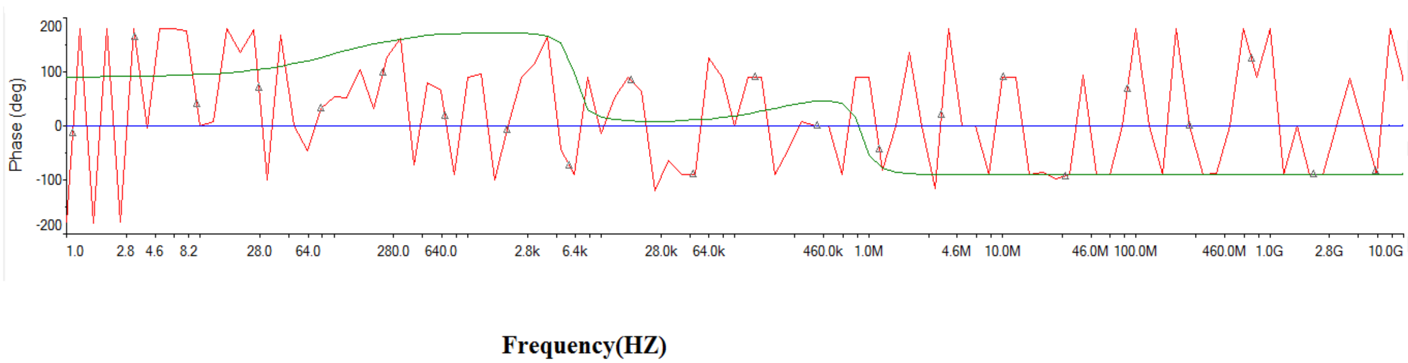

Figure 16

Depicts the AC analysis of series inverter.The output increases as the input decrease a particular period of time remains constant.

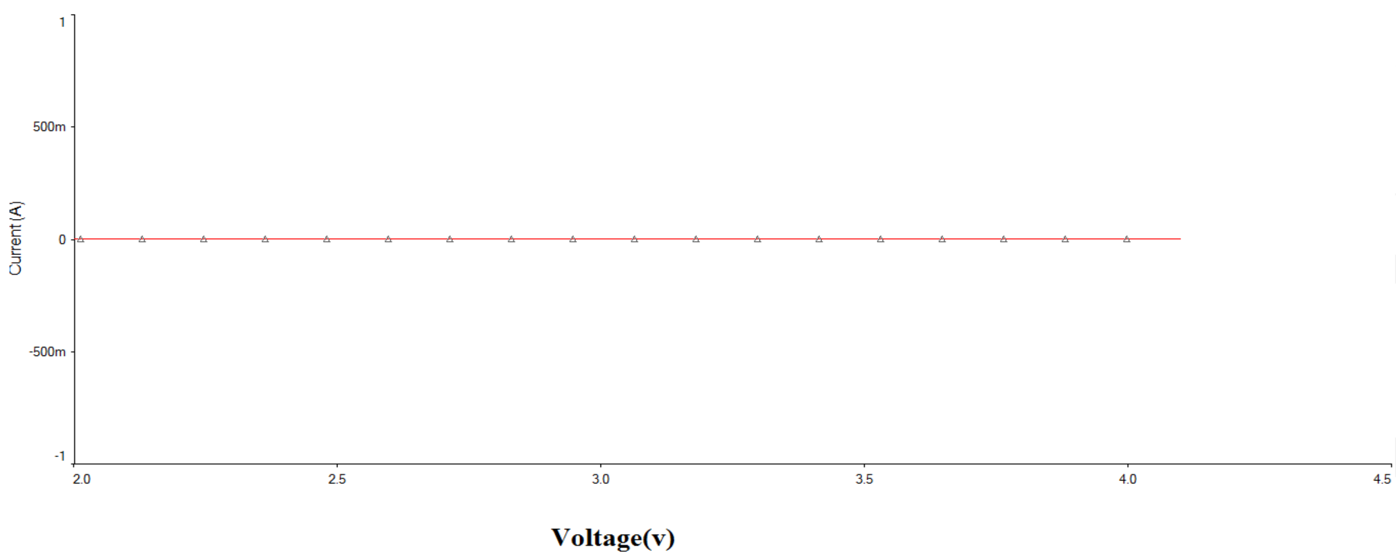

Figure 17

Depicts the transient analysis of series inverter. The output signal constant with the input signal

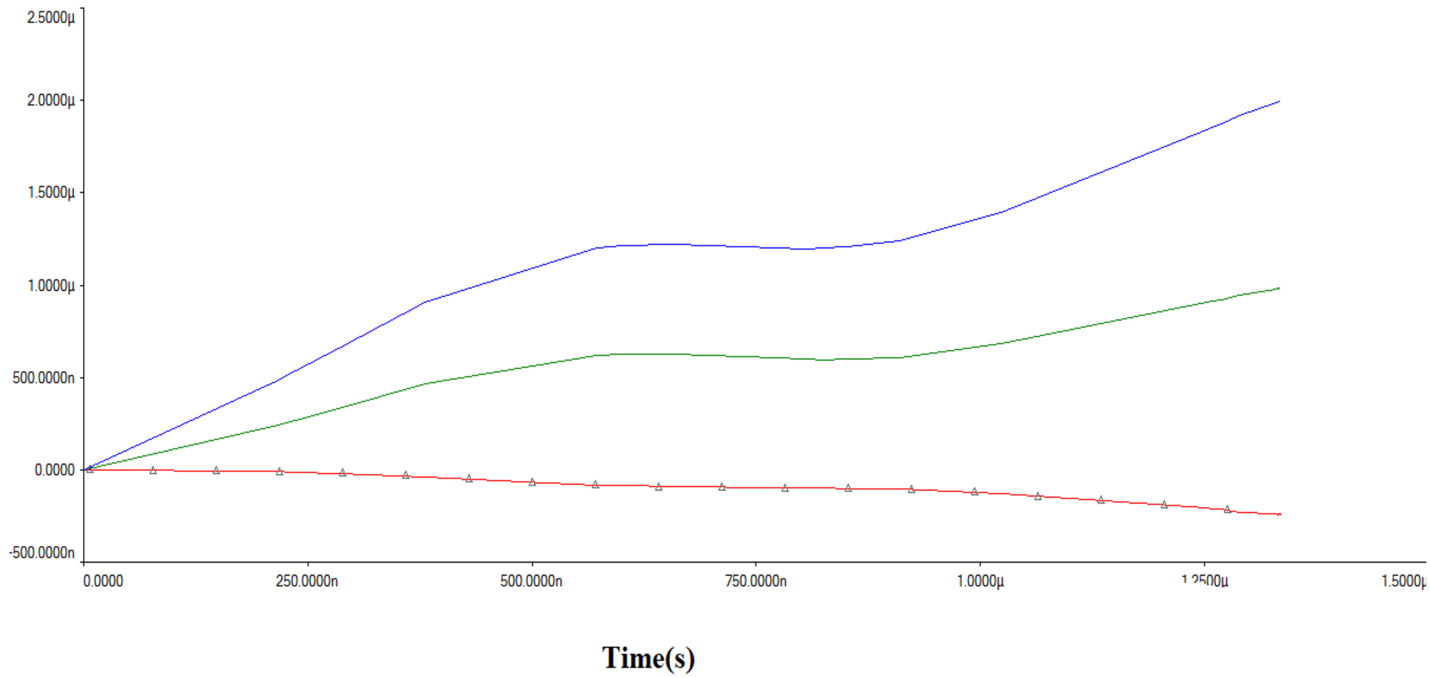

Figure 18
Depicts the Dc analysis of series inverter. The output increases as the input increases and remains increased.

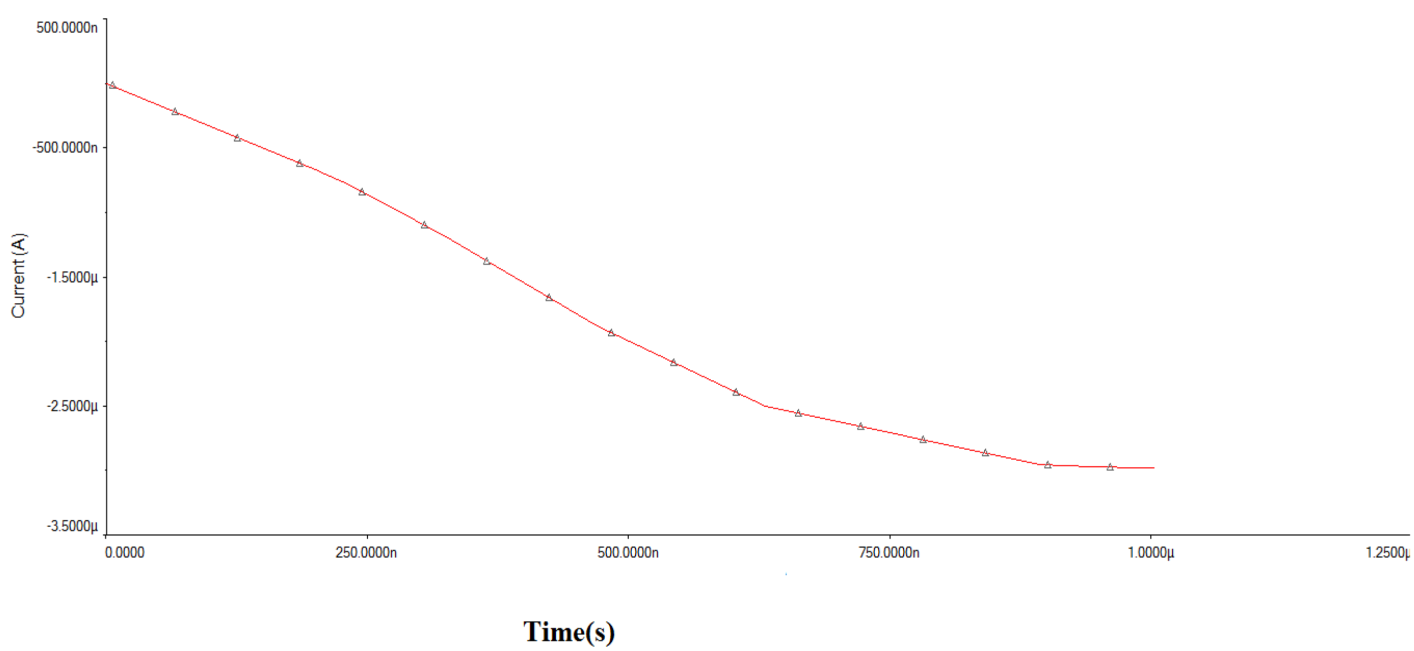

Figure 19
Depicts the temperature sweep a series inverter. The constant decreased in the output is observed as the input increased

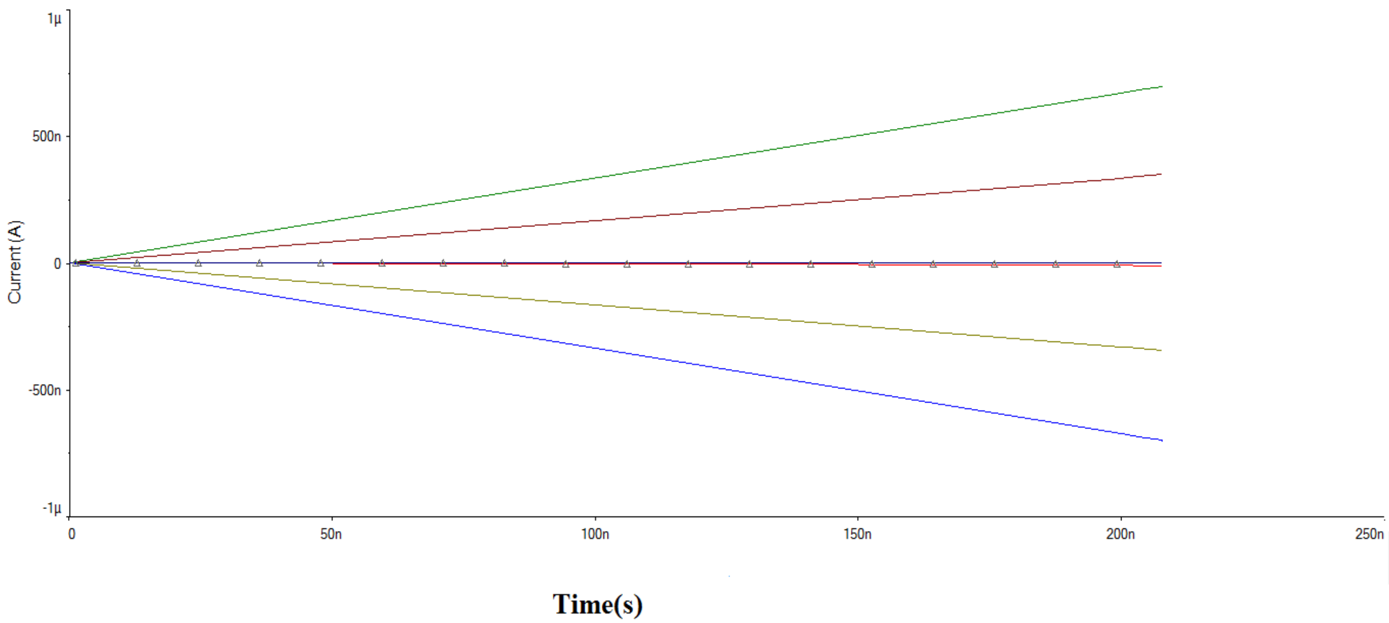

Figure 20

Depicts the Parameter sweep a series inverter. The output increases the short period of time and remains constant

5. CONCLUSION

In this paper, after having compared the wave forms of PSPICE simulation and real time experiment. It is quite obvious the selection of IGBT as a power semiconductor switch the high-frequency hybrid resonant inverter is advantageous for induction heating purposes for frequency below 50khz and highly acceptable. IGBT offers highest RMS value of coil current among all the probable configurations using different power semiconductor switches. For a frequency range of above 50khz, MOSFET will be a better option due to lowswitching& conduction losses. Finally, MOSFET based series resonant inverter circuit analyzed for induction heating under two modes of operationWhere the output clearly describe the MOSFET can be the best device for induction heating applications in terms of speed and efficiency and it was the better option mainly because of its low switching loss and by its overall performance.

REFERENCE

1. KevadiyaKetan, BhattSachin, BaldhaPrince, ButaniVijay, Jignesh Josh.Simulation of IGBT Based Power Supply for Induction Melting Furnace. International Journal of Engineering and Techniques.vol.2, No.1, pp:83, (2016).
2. Ramya L.R., Sowmya D.B, Nandish B.M. MOSFET based three phase bridge inverter for induction heating applications. International Journal of Scientific Development and Research. vol.1, no. 5, (May 2016).
3. Ronal S. SwapniV, Arya. Triggering Circuit of Induction Furnace With Power Quality Analysis. International Conference on Electrical, Electronics, and Optimization Techniques. pp:1-6, (2016).
4. Kulkarni. V.V**,** Swami. L.B.MOSFET Based High- Frequency Inverter for Induction Heating Equipment Using MATLAB/SIMULINK environment. International journal of innovations in engineering research and technology. vol. 1, Issue 1, (Nov-2014).
5. Vasudha Gujar. Design and Development of LCL Resonant InverterFor High –Frequency Induction Heating Applications. ISSN: 2348-4748.volume 1, No.4, (April 2014).
6. Mehar Ali Md, Srinivasu. R, Jyothsna.T.R. Phase locked loop control of 50-150 KHz Half- Bridge Resonant -type Inverter for Induction Heating Applications.vol. 4, No. 8, pp.21-27, (August 2014).
7. Nithya. R, Anila. N.P, Mohan.J. Analysis of Series Resonant Inverter using Hysteresis Current Control.vol 8, no. 2.pp:01, (Feb 2014).
8. Govindaraj. T, Muthuraja. T. Simulation Modeling on ZVS Based MOSFET Inverter and IGBT Converter Fed PMDC Drive. vol. 2, No. 1, ISSN (Online) 2321 – 2004, (January 2014).
9. Hakim. A Razzaque Shaikh, Shravan Kumar, Akireddy. Simulation of MOSFET Based Inverter for Induction

Heating In MATLAB. Volume 4, No. 11, ISSN (Online): 2319-7064, (2013).
10. Gayathri. K, Devi. S, Hema and. V,Suresh. A. Analysis of series resonant inverters with PWM and PDM techniques for industrial heating applications. vol. 4, No. 2, pp:1-27, (june 2012).
11. Pradip Kumar Sadhu, Nitai Pal, and Atanu Bandyopadhyay. Choice of Semiconductor Switches for Energy Efficient Induction Heated Pipe-line using H. F. Mirror Inverter. vol. 26, no.2, pp:64, (2012).
12. Yongxin Wang, Yabin Li, Yonglong Peng, Xingkun Qi. Research and Design on IGBT Induction Heating Power Supply. pp: 20-32, (2012).
13. Turki. K., Hassan, Enaam A. Ali. Power Control of Series-Parallel Resonant Inverter For Induction Heating Using Buck Converter. vol 28, no 10, pp: 35, (2010).
14. Java. H, A, Shoulaie. Analysis of H-bridge Current Source Parallel Resonant Inverter for Induction Heating.volume 3, pp: 435-440,(2009).
15. R. Soni, Hirenkumar D. Patel, Mr. N. D. Patel, Mahendra Rathod. Hardware Implementation of MOSFET Based High-Frequency Inverter for Induction Heating.vol. 02, no.02.